FOREST HEALTH PROTECTION
South Sierra Shared Service Area

Report No. SS09-07

April 7th, 2009
File No. 3420

To: Teresa McClung, District Ranger, Calaveras Ranger District, Stanislaus National Forest

Subject: Evaluation of Two Red Fir Units Proposed for Management in Bear Valley Ski Area, Calaveras Ranger District, Stanislaus National Forest

At the request of Patti Clarey, Public Service Program Area Leader, Forest Health Protection (FHP) staff conducted an evaluation of general stand health in two units proposed for treatment on the Calaveras Ranger District, Stanislaus National Forest (STF) on November 24th, 2008. The objective of this visit was to identify current stand conditions and provide management recommendations to improve overall forest health. This report summarizes: 1) stand characteristics, disturbance agents, and mortality values for two units proposed for treatment, 2) mortality data from local, STF Forest Inventory and Analysis (FIA) plots, and 3) potential treatment options.

District personnel identified the following objectives for us to base our recommendations on:

- Provide recreational opportunities for the general public that, in turn, can provide economic benefit to the local community
- Promote visitor and local community safety by minimizing tree mortality to reduce the potential for hazardous tree failure and hazardous surface fuel loading buildup
- Promote individual tree vigor and overall forest health to maintain vegetation that has the resilience to respond to, or recover from, disturbance events
- Maintain a mature forest component of large diameter trees

As the first stipulation is outside the realm of forest health, this report focuses on the later three objectives.

Observations

Mokelumne West

Forest insect and disease disturbance agents and stand characteristics were surveyed with 1/20th acre fixed plots adjacent to the Mokelumne West ski run on Bear Valley Mountain (Table 1; Pictures 1 & 2). Elevation in this area was 7790 ft., average slope was 35% (range 15-45%), and stands had east to southeast aspects.

Table 1. Bear Valley Stand Conditions for Unit Near Mokelumne West Ski Run

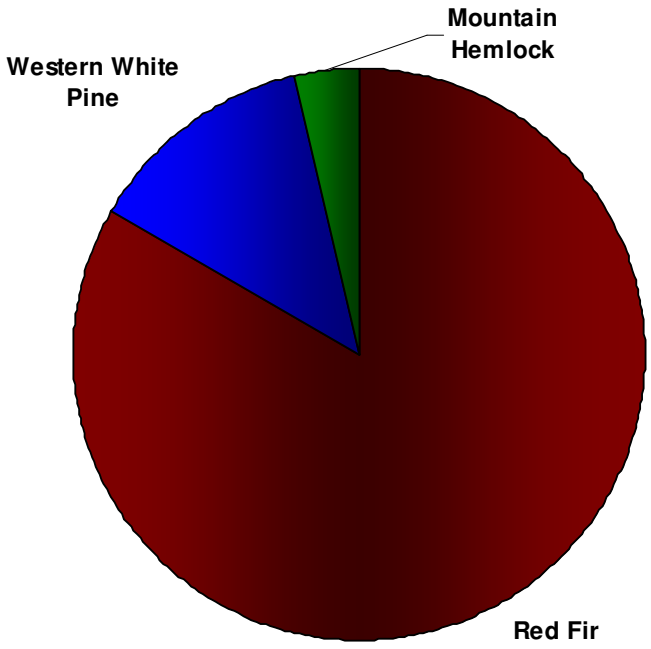
Stand Characteristic	Mean	Minimum	Maximum
Trees Acre^{-1} (TPA) >4" DBH	484	340	920
Basal Area (ft.^{2} acre^{-1})	520	155	1056
Stand Density Index	636	250	1151
% Red Fir TPA >4" DBH	83%	79%	91%
% Western White Pine TPA >4" DBH	13%	7%	18%
% Mountain Hemlock TPA >4" DBH	4%	0%	11%
% Pine w/ White Pine Blister Rust	87%	67%	100%
Recent Pine Mortality (Trees Plot^{-1})	1.2	0	5
% Red Fir Regeneration < 4" DBH	96%	88%	100%

Picture 1. Typical density for the unit near Mokelumne West ski run

Picture 2. Canopy layers for unit the near Mokelumne West ski run

Species composition was primarily California red fir (*Abies magnifica*) with clumps of western white pine (*Pinus monticola*) and scattered mountain hemlocks (*Tsuga mertensiana*) (Figure 1). The red fir and western white pines were found in all the canopy layers and diameter classes while only larger diameter, > 30" diameter at breast height (DBH), mountain hemlocks were observed (Table 2A). Conifers were often spatially distributed in pockets that had similar diameter/crown dominance classes. Stand density index (SDI) values averaged near 600.

Figure 1. Species Composition for Unit Near Mokelumne West Ski Run (based on trees acre^{-1} >4" DBH)



Red firs had a typical "inverse J-shaped" diameter distribution curve indicating multiple years of continued, successful recruitment (Figure 2). Little western white pine regeneration was observed and the only seedlings/saplings detected were located under canopy gaps. No mountain hemlock regeneration was observed (Table 2).

Figure 2. Mean Species Distribution by Diameter Class for Unit Near Mokelumne West Ski Run

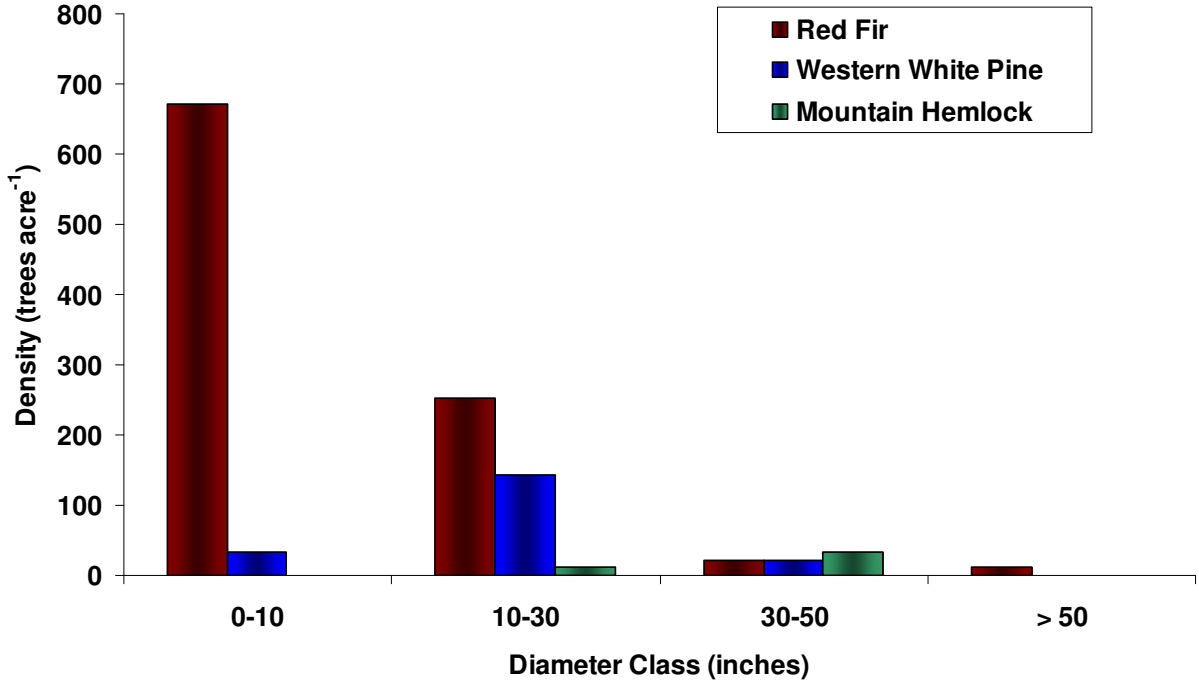


Table 2. Diameter Statistics by Species for Overstory and Regeneration for Unit Near Mokelumne West Ski Run

	A. Trees > 4" DBH			B. Regeneration < 4" DBH		
Species	**Mean**	**Min**	**Max**	**Mean**	**Min**	**Max**
Red Fir	14.5	4.3	63.7	1.0	0.2	3.7
Western White Pine	18.2	6.2	41.6	2.5	1.5	3.5
Mountain Hemlock	37.8	29.3	44.1	0.0	0.0	0.0

Red firs had little occurrence of red fir dwarf mistletoe (*Arceuthobium abietinum* f. sp. *magnificae*) and/or Cytospora cankers (*Cytospora abietis*) as ≈ 3% exhibited symptoms. Infected trees had a Hawksworth dwarf mistletoe rating (DMR) of 1 (Hawksworth & Weins 1996). Older mortality (> 5 years) occurred in ≈ 1 large diameter (>30" DBH) fir acre^{-1} had evidence of fir engraver (*Scolytus ventralis*) and/or roundheaded fir borer (*Tetropium abietis*) attack.

Over 85% of the mature western white pines and virtually all of the pine regeneration had blisters, branch cankers, branch flagging, and/or top-kill characteristic of white pine blister rust (caused by *Cronartium ribicola*) (WPBR) infection. Recent mountain pine beetle-caused (*Dendroctonus ponderosae*) mortality occurred in a group of seven trees averaging 20" DBH (range 12-39") that were attacked in 2007/2008. The largest, 39" DBH tree was likely the "focal tree" based on needle retention rates. Five out of these seven pines also had symptoms of WPBR infection.

Spring Cliff Road Unit

Forest insect and disease disturbance agents and stand characteristics were surveyed with multiple variable radius plots using a 40 basal area factor prism along the unit proposed for management north of Spring Cliff Road near the southern end of Bear Valley Ski Area (Pictures 3 & 4). Portions of this unit bordered housing residences. Elevation in this area was 7357 ft., average slope was 10% (range 0-20%), and stands had southern aspects.

Picture 3. Housing unit and typical canopy layers for unit near Spring Cliff Road

Picture 4. Old and new mortality associated with a root disease center in unit near Spring Cliff Road

Species composition was 90% red fir and 10% western white pine that were distributed in multistoried stands with two distinct canopy layers of mature trees and an understory layer with immature trees. Virtually all of the immature trees were red fir and no western white pine regeneration was detected. The upper canopy layer was composed of average 28" (range 20-45") DBH conifers while the lower layer had average 15" (range 7-20") DBH trees. Stand basal area averaged 270 (range 200-360) $ft.^2$ $acre^{-1}$.

Dwarf mistletoe infection and/or Cytospora cankers occurred in ≈ 35% of upper canopy red fir with 1 - 3 DMR. In the lower canopy, infection occurred in ≈ 15% of the fir with 1 DMR. Recent mortality (≤ 5 years) occurred in ≈ 1.5 fir trees $acre^{-1}$ of large diameter fir located in the upper canopy layer. Older mortality (> 5 years) was detected in a pocket of 10 trees that were likely associated with Annosus root rot (*Heterobasidion annosum*). Laminated decay was found in the xylem tissue of these trees but no characteristic fruiting bodies (conks) were located. Both the recent and older red fir mortality had symptoms of fir engraver and/or roundheaded fir borer attack.

Discussion and Management Options

Disturbance dynamics have been documented for similar red fir/western white pine forest types on the west side of Lake Tahoe located ≈ 43 miles north and slightly west of Bear Valley Ski area (Scholl & Taylor 2006). Typically, these overmature stands experience frequent small-scale disturbances caused by localized insect attack, windthrow, or small fires that create areas for recruitment. Western white pine is a shade-intolerant species that is generally dependant on these disturbances to create suitable canopy gaps and bare mineral soil needed for seed germination and regeneration success. Moderate severity fires are generally infrequent (2 were documented in last 400 years in Lake Tahoe study sites) but can contribute to spatially extensive recruitment pulses when and where they occur. The varied scales of these disturbances can result in an all-aged forest where trees with similar diameters have varied ages (Scholl & Taylor 2006).

No Management

Small-scale disturbances and mortality will likely continue at current rates and may increase as stand density increases (see Appendix A) in the units near Mokelumne West and Spring Cliff road. Mortality is most likely in trees that are physiologically stressed by root disease, parasitic plants, competition, and/or drought as these trees are more susceptible to insect attack. Additionally, pathogen and parasitic plant infections will likely increase in severity within infected hosts and create new infections in surrounding trees.

Red fir mortality increased in recent years on the Stanislaus National Forest (Region 5 FHP report SS07-01). Red fir STF FIA plots with stand densities similar to the proposed units averaged ≈ 9% or 40 trees $acre^{-1}$ of new and old mortality (estimated ≤ 30 years dead) that was primarily distributed in 10-20" and larger diameter classes (Appendix A). These numbers do not reflect the exact levels of mortality that will occur; however, they represent the best available science to estimate minimum potential mortality and assess whether treatments are necessary to meet vegetation objectives.

Recent MPB-caused western white pine mortality occurred within the Bear Valley Ski area surveyed units and few large diameter, overstory pines remain in these stands. The attacked

pines were all infected with WPBR and surrounded by high densities of competing vegetation. Further MPB-caused mortality should be expected without management and the western white pine component of these stands will likely diminish in subsequent years.

Option 1 Sanitation Thinning

Thinning red fir stands with an emphasis on sanitation can promote individual tree vigor and resistance to insect attack or other disturbances by reducing competition and by increasing growth rates and the defensive capacity of residual trees. Overall stand health can be improved by removing trees infected with pathogens or parasitic plants to reduce inoculum sources for new host infection.

Few studies have evaluated the long-term effects of thinning red fir stands. The nearest study to the Calaveras Ranger District took place on the Klamath National Forest in South Oregon (Zhang et al. 2005). Stands were initially thinned then followed for 28 years. Treatments included light thinning (to 320 SDI), heavy thinning (to 100 SDI), and non-thinned stands (with 800 SDI). Heavily thinned stands had no mortality during the study period, lightly thinned stands only had mortality after stands exceeded 600 SDI (27% in last 5 years of study), and non-thinned stands had extensive mortality throughout the study (65% over 28 years). The distribution of larger diameter red firs (>40" DBH) increased in the heavily thinned plots (Zhang et al. 2005). District personnel indicated desired conditions for stands near Spring Cliff Road included a greater distribution of trees exceeding 36" DBH. Thinning can release trees near this diameter threshold that can grow to meet these desired conditions.

The STF FIA plots also provide indirect evidence that thinning can reduce mortality in red fir-dominated stands. They depict a negative association between mortality and stand density index (Appendix A) and plots with >500 SDI had twice the mortality of plots <500 SDI on average (Table 3).

Table 3. Mean Mortality Values for Red Fir FIA Plots on the STF

	Plots < 500 SDI	Plots > 500 SDI	All Plots
Number of Plots	11	14	25
Mortality (trees acre^{-1})	21	43	33
Percent Mortality	5%	11%	8%

Calculations included old and new mortality estimated at ≤ 30 years since death.
Data obtained from: http://www.fs.fed.us/r5/rsl/projects/inventory/inv-download.shtml

Trees in which mortality is likely or those that are sources for pathogen or parasitic plant inoculum should be preferred for removal. These include red fir within root disease centers, fir with declining crowns (Appendix B – High Risk), or those infected with dwarf mistletoe and/or Cytospora cankers (Appendix B). Western white pine with symptoms of WPBR infection should be considered for removal if they have severe stem infections, dead tops, or heavy branch infections. Pines with minor branch infections should be considered for retention; otherwise, virtually all pines would be removed.

Wind Damage

Vegetation removal to reduce potential mortality can expose residual trees to increased risk of direct (uprooted trees or broken stems) or indirect damage (as falling trees collide with adjacent stems) caused by high wind velocities. Wind damage was studied in overmature white and red fir stands that had partial or patch cut treatments north of Lake Almanor, Lassen National Forest (Gordon 1973). Within six years of treatment, trees on the periphery of the patch cuts had ≈ double the amounts of direct damage (5-9 trees acre^{-1}) compared to trees in the partial cut units (3 trees acre^{-1}). The majority of damaged trees (60%) were distributed in intermediate and suppressed crown classes. Wind velocity data was not recorded on-site and the nearest weather station indicated gusts and sustained wind speeds ≥ 40-55 miles hour^{-1} were possible (Gordon 1973).

Patch and partial cuts are being considered for the respective units near Mokelumne West and Spring Cliff road. Sanitation thinning can remove stems susceptible to wind damage but would also reduce protective wind buffers surrounding or within these treatment units. Local knowledge of potential wind speeds and previous wind damage should be considered to assess residual vegetation risk. Thinning should not be considered if anticipated wind damage exceeds benefits from sanitation removal. If minimizing wind damage and benefits from sanitation thinning are both desired, multiple thinning management entries varied through time can improve wind firmness in residual trees while reducing vegetation competition.

Trees that have a high potential for direct wind damage should be preferred for any sanitation removal. These include trees in the suppressed or intermediate crown dominance classes, fir within two tree-heights of a root disease center, fir with DM brooms, and trees with severe leans, butt rot, cat-faces, or any other openings for pathogen introduction. Felling or skidding damage to residual trees should be minimized to reduce new infection courts for pathogen colonization.

Preventative Root Disease Treatment

Regional policy (FSM 2303 & FSH 3409.11, Chapter 60) for designated recreation areas requires preventative application of a registered borate fungicide (such as Sporax) to all freshly cut conifer stumps. Application is recommended within 4 hours of felling. This treatment can reduce the spread of Annosus root disease; which, in turn can reduce the potential for tree mortality and hazardous tree failure.

Option 2 – Superior Stock Seed Retention

To our knowledge, local western white pine seed stock resistant to WPBR is not currently available for planting. The small numbers of western white pine regeneration (see Figure 2) are virtually all infected with WPBR and few will likely survive and grow to replace larger diameter pines in the overstory. The majority of overstory western white pines in the Bear Valley ski area units surveyed are infected with WPBR and many have recently been killed by mountain pine beetles. Extensive mortality caused by MPB has recently occurred in many high elevation white pines across the western United States (Gibson et al. 2008). Less than 10% of western white pines are resistant to WPBR. The population of potentially resistant trees has declined in recent

years and will likely continue to be reduced. If maintaining a component of historic western white pine vegetation in these units is a priority, then identification, collection, storage, and planting of seedlings reared from superior stock seed is recommended.

Additionally, we recommend creating a vegetation management plan to develop a long-term strategy to meet specific desired vegetation goals and objectives such as: species composition, density levels for diameter or crown dominance classes, desired recruitment levels, acceptable/unacceptable mortality levels, recreational potential, etc. This plan should also identify the range and timing of any projects needed to meet and maintain these desired conditions.

Please contact us with any additional questions. We are available to provide additional input or training on forest insect or disease-related issues.

/s/ *Joel M Egan*

Joel M Egan
Entomologist
Forest Health Protection
(209) 532-3671 x290
jegan@fs.fed.us

Beverly Bulaon
Entomologist
Forest Health Protection
(209) 532-3671 x323
bbulaon@fs.fed.us

Martin MacKenzie
Pathologist
Forest Health Protection
(209) 532-3671 x242
mmakenzie@fs.fed.us

cc
Patti Clarey
Dave Vosti
Kendal Young
John Schmechel
Deb Romberger
Susan Skalski
Sheri Smith
Phil Cannon
Dave Bakke
Julie Lydick

Works cited

Gibson, K. et al. 2008. Mountain Pine Beetle Impacts in High-Elevation Five-Needle Pines: Current Trends and Challenges. R1-08-020. U.S. Department of Agriculture, Forest Service, Forest Health Protection, Missoula, MT. 32 pp.

Gordon, D. 1973. Damage from wind and other causes in mixed white fir-red fir stands adjacent to clearcuttings. RP-PSW-90. U.S. Department of Agriculture, Forest Service, Pacific Southwest Forest and Range Exp. Stn., Berkeley, CA. 22 pp.

Hawksworth, F. and D. Weins. 1996. Dwarf Mistletoes: Biology, Pathology, and Systematics. Handbook 709, U.S. Department of Agriculture, Forest Service, Washington, DC. 410p.

Scholl, A. and A. Taylor. 2006. Regeneration patterns in old-growth red fir–western white pine forests in the northern Sierra Nevada, Lake Tahoe, USA. 235: 143-154.

Zhang, J. et al. 2005. Long-term effects of thinning and fertilization on growth of red fir in northeastern California. Canadian Journal of Forest Research. 35:1285–1293.

Region 5, Forest Health Protection, South Sierra Shared Service Area Report Cited:

Bulaon, B. and M. MacKenzie. 2007. Red Fir Decline and Mortality on the Stanislaus National Forest. FHP Report SS07-01. U.S. Department of Agriculture, Forest Service, Forest Health Protection, Sonora, CA. 16 pp.

Available at: http://www.fs.fed.us/r5/spf/fhp/sosierra/index.shtml

Appendix A – Stanislaus National Forest Mortality Data from Forest Inventory and Analysis Plots

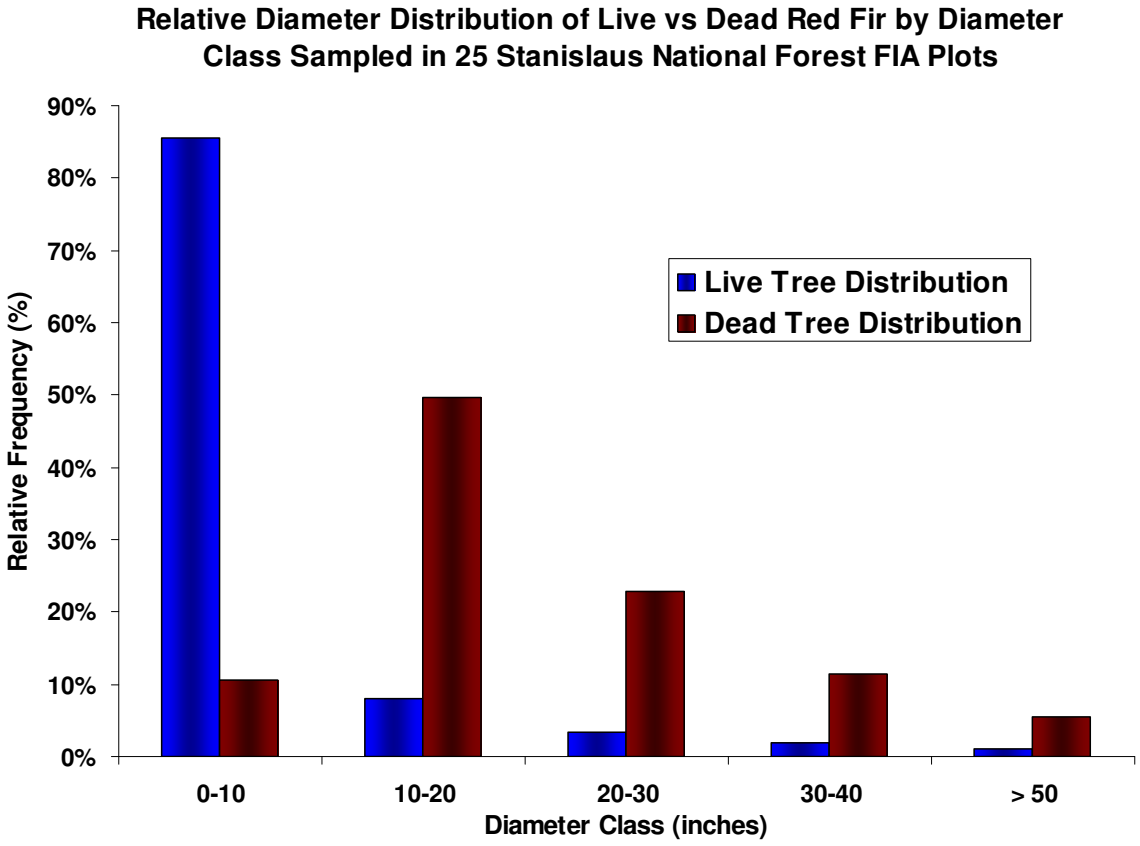


Figure A1. Chart depicts the skewed distribution of old and new mortality (estimated ≤ 30 years) towards the 10-20" and larger diameter classes compared to the distribution of live trees. The 0-10" diameter class had the greatest distribution of live trees and the smallest distribution of dead trees. Data obtained from: http://www.fs.fed.us/r5/rsl/projects/inventory/inv-download.shtml

Tree Mortality vs Stand Density Index for 25 Red Fir FIA Plots Located on the Stanislaus National Forest

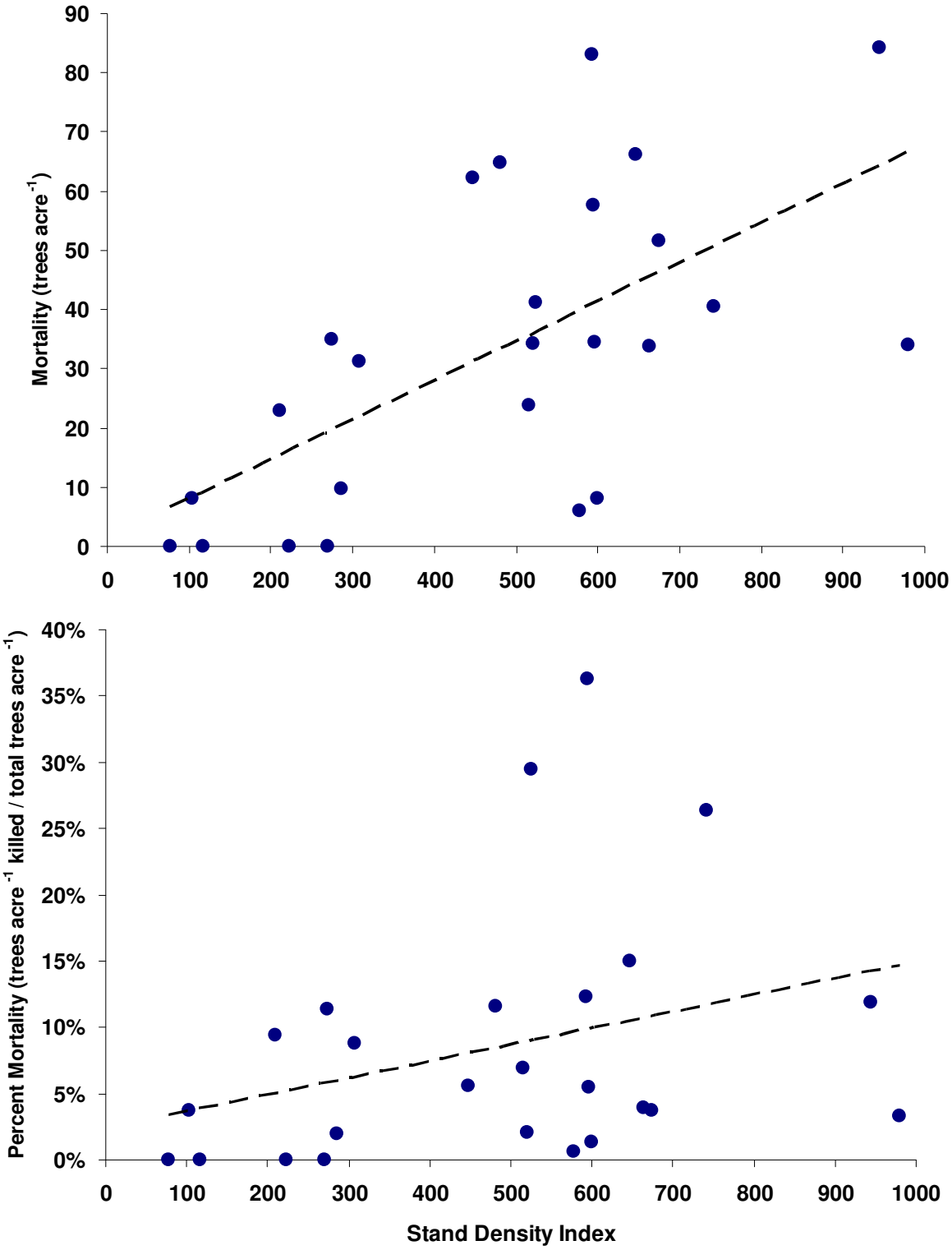


Figure A2. Plots depict new and old mortality (estimated ≤ 30 years dead) surveyed on FIA plots sampled on a yearly rotating basis. All plots have majority red fir species composition and Hawksworth DM infection ratings of 0-1 except for one plot located at x=274 SDI. Data obtained from: http://www.fs.fed.us/r5/rsl/projects/inventory/inv-download.shtml

Appendix B – Crown and Dwarf Mistletoe Indicators and Risk Levels for 10-year Tree Mortality in True Fir Species

Table B1 Expected Growth Potential Reduction & Mortality Rates in True Fir Infected with DM

	Hawksworth DM Infection Rating						
	0	1	2	3	4	5	6
Ten Year Diameter Growth Potential Reduction (%)	0.0	0.0	0.0	2.0	5.0	30.0	50.0
Ten Year Mortality (%) in Trees < 9" dbh	0.0	0.8	2.8	6.1	10.5	16.2	23.1
Ten Year Mortality (%) in Trees > 9" dbh	0.0	0.7	2.3	5.0	8.8	13.5	19.2

Data derived from: Hawksworth, F.G. et al. 1992. Interim dwarf mistletoe impact modeling system: User's guide and reference manual. Report MAG-91-3. USDA Forest Service, Methods Application Group, Fort Collins, CO. 90 p.

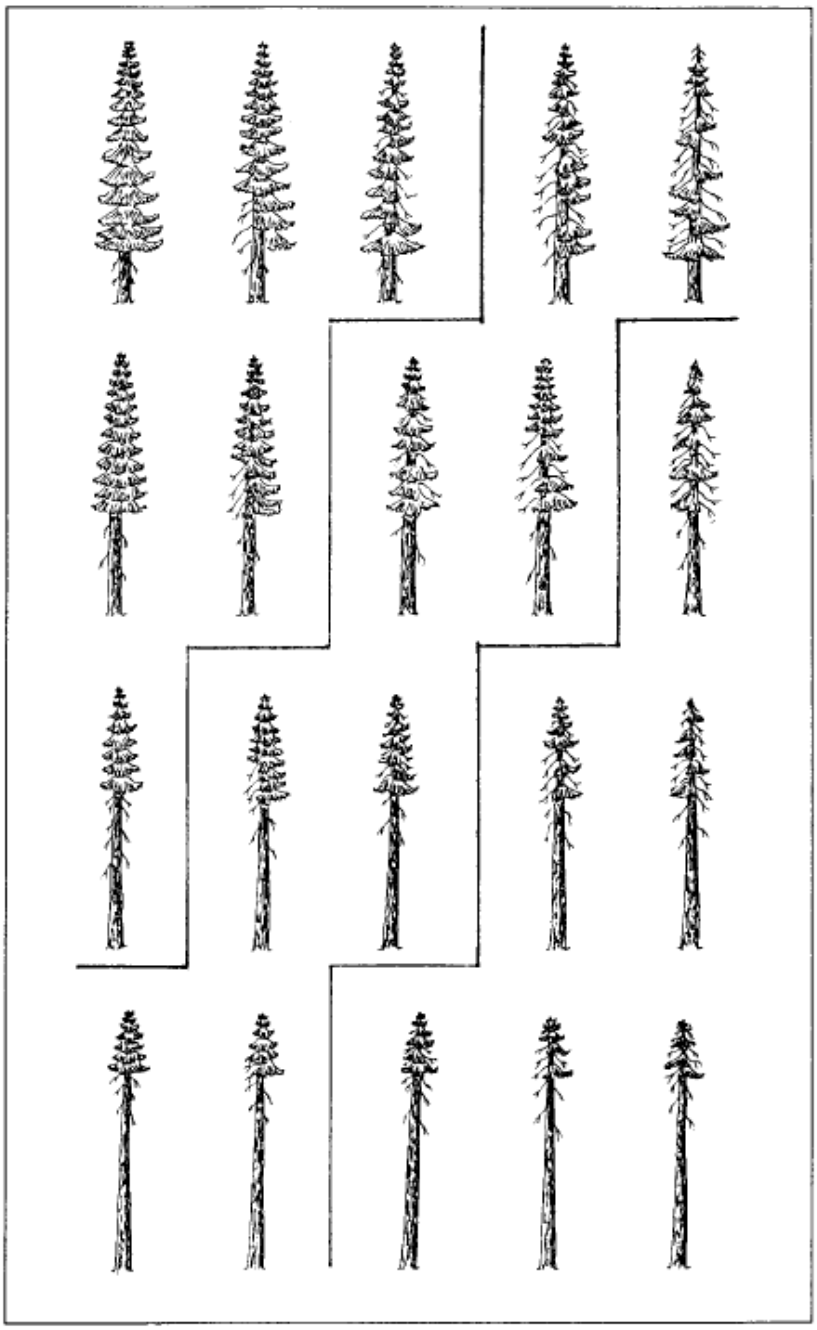


Figure B1. Risk classes for rapid visual prediction of 10-year mortality in California red fir and white fir: (left to right) low, medium, and high risk. Data from: Ferrell, George T. 1989. Ten-year risk-rating systems for California red fir and white fir: development and use. Gen. Tech. Rep. PSW-115. Berkeley, CA: Pacific Southwest Forest and Range Experiment Station, Forest Service, U.S. Department of Agriculture; 12 p.